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14. ABSTRACT
Two tasks were focused on graphene: (1) A check if traditional Fowler-Nordheim (FN) law can be used to describe field emission from single layer vertical aligned graphene. The researchers created a Klein tunneling model to show the FN law may not be valid. The results were published in APL 99, 093112 (2011). (2) It is clear that the traditional understanding or properties of the field emission is going to be very different compared to FN law. The researchers calculated the shot noise suppression due Klein tunneling for field emitter electrons. The model predicted a suppression of shot noise from the full shot noise termed as the fano factor which equals to 0.3 at low temperature.

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Final Report of AOARD 10-4110

Modeling of Electron Field Emission from Graphene

Duration: 1 year (23 June 2010 – 22 June 2011)

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Since the discovery of large size graphene in 2004, it has initiated very active research activities in understanding the unique electronic properties of graphene, including high carrier mobility, ballistic transport, and linear light-like energy dispersion relationship. Promising applications include field effect transistors, sensors, spintronic devices, and many others in nanoelectronics. In recent experimental papers, graphene has shown its potentials to be an electron source in vacuum electronics. Practical applications include being an efficient emitter for display backlight sources like LCD and LED, or even as the active emitters for field emitter flat panel display like carbon nanofibers and carbon nanotubes. If the emitted current density can be improved to high current regime, it can be also used as intense electron source for high power microwave source.

In this short report, we will present the results and outcome of works funded in this grant:

Topic 1: Revised Fowler Nordheim (FN law) for electron emission from Graphene

Since Graphene is significantly a new type of materials, it is essential to check if traditional Fowler-Nordheim (FN) law can be used to describe field emission from single layer vertical aligned graphene. We have created a Klein tunneling model to show the FN law may not be valid. The results were published in APL 99, 093112 (2011). In Fig. 1 below, we show the calculated results obtained from our model. This finding has prompt some immediate interests in planning to conduct an experiment in AFRL (Kirtland, NM) to confirm the prediction.

Topic 2: Shot noise suppression of Klein tunneling based field emission model

From the outcome in topic #1, it is clear that the traditional understanding or properties of the field emission is going to be very different compared to FN law. In this topic, we

calculate the shot noise suppression due Klein tunneling for field emitter electrons. Our model predicted a suppression of shot noise from the full shot noise termed as the fano factor which equals to 0.3 at low temperature. The results have been written up to be submitted for journal publication.

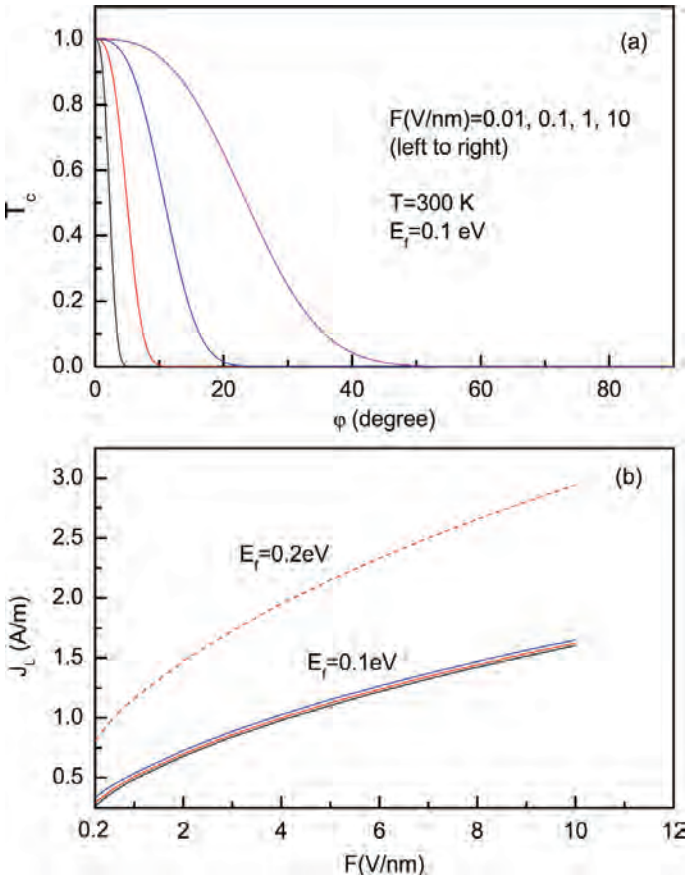

Fig. 1 Klein tunneling model

Summary

At the end of this project, we have learned of great research interests of field emission from graphene resulted from our pioneering shown in topic #1 above. Further extension of this line of work will be continued under the support of a new grant by AOARD 11-4069 (a 2-year grant with an extension for second year). We hope to have a better understanding of this new process, and hopefully can collaborate with experimental groups for some measurement that may later be developed to a high current graphene based cathode operated at very low applied field.